Effect of water supply on the tree biodiversity - soil nutrient availability relationship in forests along the soil profile

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Forests

Major terrestrial ecosystem

Affected by global changes

Mean summer precipitation

Climate Model for 2016-2035
relative to 1986-2005

IPCC – The Physical Science Basis 2013
Forests

Major terrestrial ecosystem

Affected by global changes

Mean summer precipitation

Mixed plantations may increase tree productivity

Soil functioning is still understudied

Gamfeldt et al. 2013
Nutrient cycling

Soil enzyme activity as a proxy for microorganism activity and organic matter decomposition

Objective

How will water supply influence the effect of tree diversity on soil microorganism activity along the soil profile?
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How will water supply influence the effect of tree diversity on soil microorganism activity along the soil profile?

Hypothesis:

- Root stratification and niche complementarity

Biodiversity effect

Synergistic

Additive

Optimal

Drought

Water resource
Experimental site: ORPHEE

10-year-old platform in southwestern France (part of TreeDivNet)

- Silver birch (*Betula pendula*)
- Martime pine (*Pinus pinaster*)
- Mixed species plot: Birch + pine

Irrigated blocks vs. 100 trees per plot
Experimental site: ORPHEE

10-year-old platform in southwestern France (part of TreeDivNet)

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Irrigated blocks vs. non-irrigated blocks

Diversity

Irrigation

100 trees per plot
Methods

- Sampling in March 2018: 4 soil cores x 5 depths in studied plots

- Soil analyses:
  - Available N ($\text{NH}_4^+ + \text{NO}_3^-$) and available P ($\text{PO}_4^{3-}$)
  - 7 soil hydrolytic enzyme activities
    - C-related
    - N-related
    - P enzyme

- Root data: biomass density and length

- Data analyses: 1. Redundancy analysis (RDA)
  2. Mixed models
Results: an overview

Legend

- Enzymes
- Carbon enzymes
- Nitrogen enzymes
- Phosphorus enzyme

Legend

- Enzymes

- Carbon enzymes
- Nitrogen enzymes
- Phosphorus enzyme
Results: an overview

Legend

- Enzymes
- ‘Environmental variables’

Available N (NH₄⁺ + NO₃⁻)
Available P (PO₄³⁻)

Root biomass
Root length
N-acetyl-glucosaminidase
Leucine aminopeptidase
Acid phosphatase

Carbon enzymes
Nitrogen enzymes
Phosphorus enzyme
Nitrogen availability

### Statistical results

<table>
<thead>
<tr>
<th>Trait</th>
<th>p-value</th>
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<tbody>
<tr>
<td>Diversity</td>
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![Water Treatment](#)

**Available nitrogen**

(mg N / g dry soil)

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>0-5</th>
<th>5-15</th>
<th>10-15</th>
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**Water Treatment**

- Control
- Irrigation

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Nitrogen availability

Statistical results

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Available nitrogen

(mg N / g dry soil)

Total root biomass

(kg / m³)

Water Treatment

- Control
- Irrigation

Depth (cm)
Phosphorus availability & C:P enzyme ratio

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Available phosphorus (mg P / g dry soil)

Depth (cm)

Species
- Birch
- Birch + Pine
- Pine
Phosphorus availability & C:P enzyme ratio

### Available phosphorus (mg P / g dry soil)

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### Ratio of C enzymes to P enzyme

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Species

- Birch
- Birch + Pine
- Pine

**Statistical significance levels:**
- n.s.: not significant
- ***: p < 0.001
- **: p < 0.01
An overall trend

Ratio of C enzymes to P enzyme

Available phosphorus
(mg P / g dry soil)

R² adj = 0.253
p < 0.001
Conclusions

Different responses along the soil profile

Top soils: - N
Deeper soils: + N
Mid soils: + P?
+ C:P enzyme
No effect

Upcoming studies on belowground processes  temporal complementarity
Thank you.

Funding: